From core to periphery: workplace evidence of GVCs restructuring in the Italian auto industry

Armanda Cetrulo[1], Claudia Collodoro[2], Linnea Nelli[2], Maria Enrica Virgillito[1]

[1] Institute of Economics, Sant'Anna School of Advanced Studies,
Piazza Martiri della Libertà 33, 56127 Pisa, Italy

[2] Department of Economic Policy, Catholic University of the Sacred Heart,
Via L. Necchi 5, 20123 Milan, Italy

Abstract

In this contribution, we analyse the impact of the decarbonisation process on the recomposition of the global automotive chain at the Italian level. To do so we use a mixed-strategy methodology with which we hold together a quantitative or corporate dimension as well as a qualitative or workplace-based one. With the former, we seek to investigate technological regimes with respect to knowledge production for the electrification of the car. While with the second, we analyse the results of a field analysis of two car component plants affected by the restructuring of their production. Employing a qualitative analysis that includes semi-structured interviews with HR professionals, managers or technicians and workers, we are able to highlight some relevant aspects of this transformation, such as (i) the central role played by technical-organisational capabilities, (ii) the dynamics of internal competition within MNCs and (iii) and how the combination of these two elements impact the reconfiguration of the sector. We find that no case can be defined as a successful example of transition. Rather the two cases can be distinguished between a *tentative* and a *failed* transition. Decarbonization has affected the restructuring of the value chain by a downgrading of component manufacturers between different tiers for one case, while the decarbonization process is challenging the core positioning of both cases, progressively shifting towards a peripheral positioning in the sector. Finally, despite the different outcomes of the two analysed transition cases, we still recognise the wide uncertainty that characterises the industry's transition toward electric power-train systems.

Keywords: automotive sector, decarbonization, restructuring of GVCs, innovative regimes, mixed-strategy methodolog

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1 Introduction

Technological change, decarbonization and delocalization of production are among the main structural changes occurring in the manufacturing sector. In particular, the automotive sector is the archetype of such productive transformations (Krzywdzinski (2019)). Automation and digitalization have been introduced since the 1980s, making the automotive industry one of the most technologically advanced sectors and determining a continuous reshaping of work (Krzywdzinski (2021)). At the same time, this industry is undergoing a deep transformation of the production due to the shift to the electrification. In fact, the transport sector is responsible for about 20% of the overall CO2 emissions,[1] and international institutions are pushing towards the decarbonization of the sector.[2] The automotive industry is also characterised by an inner structure of core vs periphery with respect to the specialization along the value chain (Pavlínek (2020), Pavlínek (2023)). Technological change and the decarbonization are thus leading to a reconfiguration of the geographical structure and possibly to an enhancement of this dichotomy. Digitalization, in fact, has speeded up the relocation of labour intensive production processes with low technological upgrading to low-wage countries, while maintaining technologically advanced processes in core countries. At the same time, decarbonization implies value chain disruptions which exacerbate the vulnerability of peripheral countries and plants. The periphery is in fact specialized on second and third tier suppliers of parts and components related to the internal combustion engines (ICEs). Conversion of the production depends on the decarbonization strategies of the Original Equipment Manufacturers (OEMs) in relation to: (i) imports, mostly from Asian producers, (ii) manufacturing of batteries for electric vehicles (BEVs) and (iii) the decision on which plant to allocate production to (Pirie et al. (2022)).

The decarbonization through electrification of the sector is driven by the Asian car manufacturers, leaders in the production of BEVs and electric mass-market cars. This implies a harsh price competition for European players reflected on the occupational dynamics and on the quality of jobs. In terms of labour quantity, peripheral countries and plants and low-skilled workers are foreseen to be the most affected. Core countries/regions/plants are expected to be more prompt to a conversion or to host new sustainable activities thanks to the degree of knowledge and innovation activity, while the periphery is expected to suffer from value chain disruptions caused by the ending of polluting activities and the dismissal of related jobs. As for labour quality, in addition to cutting labour costs through automation, digitalization and delocalization, companies reduce labour costs by lowering wages, a strategy European players are resorting to a greater extent to cope with price competition both in the core and in the periphery.

This contribution aims to analyse the European automotive recomposition by considering the theoretical framework of GVCs and core-vs-periphery perspective. In fact, the techno-organisational reconfiguration together with the need to decarbonise manufacturing are accelerating European restructuring of automotive

[1] https://www.iea.org/data-and-statistics/charts/global-energy-related-co2-emissions-by-sector

[2] For more details about the European Union regulations see https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/co2-emission-performance-standards-cars-and-vans_en

GVCs. In particular, we bring further evidence on how participation in value chains may not lead to productivity enhancement (Cresti et al. (2023)). In other words, we challenge the narrative according to which entering GVCs is a neutral and deterministic process of improvement for the production fabric. On the contrary, as various evidences show (Riccio et al. (2022), Cresti and Virgillito (2023)), the ascent up the development ladder is influenced by a plethora of elements, such as (i) the learning and absorptive capability of industrial and organizational competences, (ii) corporate development strategies of the players involved, (iii) the responsiveness and activation capacity of the workers involved in the transformation process, among others.

To analyse the effects of techno-organisational changes and of electrification of production in the automotive industry, we have conducted a field-work in two plants of Tier 1 components' producers in Italy. Both are subsidiaries of multinational players and produce ICEs parts for European and non-European OEMs. The plants are both located in an homogeneous geographical area characterized by process of transition toward the electrification. By looking into plant-level dynamics, we ask the following research questions:

1. What relationship, if any, is there between the decarbonization process and the restructuring of value chains? Is the decarbonization process restructuring the Italian automotive GVCs? Are we witnessing a downgrading or upgrading of component producers between different tiers? Is decarbonization exacerbating frictions between plants and head quarters within TNCs?
2. How do the processes of transition to electric vehicles manifest themselves at workplace-level?
3. How does the electrification of the automotive industry fit into the macro dynamic of Italian industrial downgrading?

We adopt a mixed-methodology where we combine (i) the analysis of firms' patterns at the corporate level to grasp the corporate strategy with respect to electrification and technology adoption (ii) a workplace analysis to catch the effects of such strategies on labour and organizational dynamics (Cirillo et al. (2024)). As at the corporate level, we use company data from the Bureau Van Djik Orbis IP dataset to look at the innovative regimes (by patent data), firm patterns in employment and profitability and competition in MNCs (by level of employment, sales, profitability and intangible assets). At the workplace level, a qualitative approach allows the effects of the electrification strategy on work and organisational dynamics to be captured. This setting allows us to grasp the possible consequences of the re-articulation of the sectoral value chain. We have conducted semi-structured interviews, to technical-professional workers, operational workers and workers representatives.

Decarbonization has affected the restructuring of the value chain by a downgrading of component manufacturers between different tiers: Case I is shifting from Tier 1 to Tier 2. The decarbonization process is challenging the core positioning of the two cases: the high-value localization, due to past regional industrial specialization and proximity to Universities, is not reflected in the decarbonization process and both plants emerge as peripheral within the group in the investments strategy for decarbonization, possibly leading to

frictions with the headquarters who are progressively moving away the decision-making center from these plants. Despite the active promptness of workers and capabilities to respond -especially for Case II- to the transformations at stake, no case can be defined as a successful example of transition. Rather the two cases can be distinguished between a *tentative* and a *failed* transition. Despite the production of electric products, Case I is attempting a transition since the electric products are developed in other competence centres and R&D department is lacking electronics/electric skills; the production volumes of the electric product is marginal over the total production and high uncertainty with respect to the effects of the electrification of the sector emerged in the exchange with trade unions. The fact that Case II is stuck in the production of ICE components and is tenting to innovate in the hydrogen segment while electrification is the strategy driving the transformation of the sector, results in a failed transition case.

With this paper we aim to discuss the main trends at play and provide a comprehensive understanding of the main challenges the automotive sector is currently facing. In this way, tailor-made policies for a just transition can be developed.

The reminder of the paper is the following: Section 2 summarizes the main theoretical framework of reference, the progressive evidence of restructuring of European automotive GVCs and the specificity of the electrification process of the sector and the capability-based theory within the evolutionary framework as the theoretical base that explains the ability of workers to respond to such transformations. Section 3 describes the research questions and the adopted methodology, specifically the case selection strategy and cases' characteristics by providing for descriptive evidence about firms' patterns at the corporate level; while Section 4 delves into the workplace analysis reporting the main highlights of the interviews for each case. Section 5 provides for a discussion of the main results by a comparative perspective between the two cases and Section 6 summarises the main conclusions.

2 Theoretical Framework

2.1 The restructuring of the European automotive GVCs

The process of "globalisation's second unbundling" (Baldwin (2013)) involved the beginning of trade in intermediate products, further accelerating the process of reconfiguration of production geographies. Alongside this, the development of advanced logistics systems and ICT technologies made it easier and quicker to relocate certain stages of production anywhere in the world. In the European context, this trend leads to a remarkable re-composition of the automotive industry value chain. Thus, we witness a sizeable downsizing of the industry in the Mediterranean European countries in favour of the Visengrad bloc (Pavlínek (2020)). While for the former, this has resulted in a general decrease in production and employment (in both final production and components), for the latter, this trend has led to the opening of mainly component factories. In this sense, Pavlínek (2020) highlights how the recomposition of the automotive value chain has mostly resulted in the crystallisation of the imbalances already present in the European productive fabric. In fact,

the creation of such "integrated peripheries"is preserving the centrality of the headquarters of the major European car manufacturers in the core countries and allowing the installation of lower technology and value-added activities in the peripheral territories.

More generally, recent evidences on the recomposition of GVCs seem to show how participation in them may not lead to productivity growth. As stated by Riccio et al. (2022), "An apparent neutrality in GVCs participation might instead mask deeper asymmetries and forms of dependence of developing countries vs developed ones". In line with the trends of recent years, in fact, the participation of advanced economies in GVCs leads to the reorganisation of production activities towards high value-added phases, typically pre- and post-production, accelerating the process of deindustrialisation and servitisation of core countries. In other words, the remarkable process of labour offshoring exacerbates the weakening of industrial capabilities in mature economies (Cresti et al. (2023). On the other hand, developing countries may benefit from technology transfer and knowledge spillovers, but the outcome of joining GVCs is far from deterministic. The most relevant aspects include the learning capabilities and industrial absorption capacity on one side, and the development strategies of companies relocating production to developing countries on the other (Cresti and Virgillito (2023)). Regarding companies' business strategies, it is worth mentioning that new facilities in integrated peripheries are often set up thanks to the entry of large amounts of foreign capital through FDIs. Thus, control over production, its organisation and strategic choices is exercised by foreign ownership, which may be reluctant to develop relations with the local industrial fabric, thus limiting the regional development potential of FDIs (Pavlínek (2018)).

At the European level, the geographical expansion occurred between 1990 and 2015, thanks to the inflow of around EUR 35 billion of FDI to Eastern Europe (OICA 2018), and affected the recipient countries as unevenly as it impacted the core economies. With the exception of German, in fact, the traditional European automotive industry core countries witnessed a dramatic collapse in domestic private car production between 1991 and 2017. Italian carmakers lost around a 56% of private vehicle production, French manufacturers recorded a loss of 49% and finally Sweden producers stood at a minus 24% of manufacturing production Pavlínek (2020). Equally large is the collapse in the older 'integrated peripheries', such as Belgium and Portugal (-63% and - 29% respectively). Such restructuring of the European production structure has a major impact in terms of job creation and loss. According to Pavlínek (2020), between 2005 and 2016, the automotive sector in EU + 1 has created 462,398 jobs against a loss of 478,780 unit, thus resulting in a net loss of more than 16,000 jobs.[3] Furthermore, looking at the dynamics on a regional level, we see that Western Europe recorded a net loss of 254,317 (81% of overall losses) jobs, while Eastern countries recorded a net increase of 237,935 (71% of total jobs created). Carmakers of core European countries are the main responsible for the transformation of the production and employment fabric: French and German automotive companies alone have jointly created around 51% of new jobs. This creation mostly involves component manufacturers and it is geographically highly concentrated in the integrated periphery of Eastern Europe.

[3] 10EU + 1 refers to European Union countries plus Norway.

93% of the jobs created abroad by German companies and 92% of those by French societies are concentrated in this region. Finally, only 5% of all the jobs created in Eastern European integrated peripheries are owned by local companies. This evidence suggests that participation in the automotive value chain of Eastern European countries on the one hand is often subordinated to the inflow of foreign capital and, on the other hand, does not contribute directly to the development of the local production fabric.

This dynamic of recomposition of the automotive GVCs at the European level is recently being further exacerbated by the structural change due to the decarbonisation of the industry (Pavlínek (2023), Fackler et al. (2024)). In fact, manufacturing (of which automotive is a very relevant sector in Europe) is responsible for one-fifth of overall CO2 emissions and 50% of the energy used (Dosi et al. (2024)). Thus, the restructuring briefly sketched is undergoing further recomposition that challenges the inequalities already present (in terms of wages, trade union rights, quality and safety at work) and requires a good technological absorption capacity to be socially and environmentally sustainable.

In addition, (i) the learning and absorptive capability of industrial and organizational competences, (ii) corporate development strategies of the players involved, (iii) the responsiveness and activation capacity of the workers involved in the transformation process are some of the elements that explain the entry and repositioning of the GVCs (Riccio et al. (2022), Cresti and Virgillito (2023)). Given the pervasive implications of the decarbonization process as need for skills' adaptation, GVC restructuring and market transformations, we refer to the capability-based theory to understand the ability of workers to respond. With respect to the definition of organizational capability provided by Dosi (2023) (p.215) for which a capability can be the capacity to perform a specific activity with a specific purpose, we particularly refer to the *capability, differently from an ad hoc activity, which does not reflect predicted or patterned behaviours, enables repeated and reliable performance of the underlying procedure.* What we intend to highlight is the distinctive role of organizational capabilities in assuring the probability of survival to sectoral changes as changes in technological regimes - and the decarbonization process consists in all its effects in a technological transformation (Popp (2019))- that imply firms to react and adapt by internal abilities as well as developing new required skills to cope with such transformations and survive; structural changes also implies the need to deal with the entry of new competitors into the market (Dosi (2023)).

In what follows, we describe the main sectoral changes in the Italian automotive sector. In particular, (i) the profound crisis in this industry, contextual but not necessarily consequent to the electrification of production, and (ii) the main environmental policies aimed at the transport sector in Italy. The description of the national and sectoral context is functional for a better understanding of the study cases and the workplace analysis.

2.2 Structural trends and public policies for the decarbonisation of the Italian automotive sector

The overall dynamics of the sector is primarily affected by the ongoing dissolution of the main national car producer and employer absorber, namely ex-Fiat, now Stellantis. The lack of investments by the previous corporate structures in the last decade (ex-FIAT then FCA), together with the lack of industrial strategies of the Italian government and increasing outsourcing have implied a reduction of cars production and employment (Balcet and Ietto-Gillies, 2019, Cresti and Virgillito (2023)).

According to an interview conducted with an expert of the field, the group has undertaken a clear strategic choice of exclusively maintaining the production of high-end vehicles in Italy and discarding the production of mass car products. Such corporate strategy is conducting the group toward the progressive dismantling of other production lines. On top of that, the management of the transition towards electric production is expected to further resize employment and production in the Italian plants. Today, the Italian production of Stellantis accounts only for 5% of the production of the group around the world, it employs around 50 thousand workers in the country, across 12 plants, and the corporation already asked for voluntary redundancies of 15.000 workers to manage the transition towards electric production (Bubbico et al. (2023)).

Together with the progressive decline in production of cars (from around 1,500,000 vehicles in the late 1990s to 473,000 in 2022), the production of the Italian automotive sector has become progressively specialised in the supply of components during the last three decades (Source ANFIA[4]). According to the same interviewed expert, such specialisation strategy has protected employment and production from the ex-Fiat dissolution, being the supply chain partly separated from the ex-Italian OEM, at least for some players with a diversified portfolio of clients and products. However, many plants, especially in Southern Italy, are single providers of Stellantis, thus subject to the decrease in production volumes of the group (Bubbico et al. (2023)). Overall, the Italian GVC specialisation is quite weak and dependent from an external core to activate internal production, mainly Germany, while the production of components is under the threat of further delocalization to low labour cost countries (Cresti et al. (2023)). Given such conditions, with the shift to electrification, a possible stop of the production of the final cars is envisaged.

Potential job reallocations are claimed to be achieved by investing in the employability of the workforce in new emerging productions, such as the production of batteries. However, so far, European OEMs are mainly importing batteries' components from Asia to be assembled,[5] and Asian manufacturers are investing in Europe only in the assembly of batteries' components (Pardi (2022)). In the case of Italy, the plant of Stellantis in Termoli is expected to be converted to a gigafactory by the joint venture of Stellantis.[6] However, it is still producing combustion engines (Bubbico et al. (2023)) and no clear sign of conversation is so far

[4]ANFIA Data on recent trends in production Osservatorio Auto 2023 - ANFIA, Rapporto Osservatorio Auto 2023 - ANFIA

[5]Volkswagen Group, who is planning to build six gigafactories in Europe (for more details see here.

[6]Stellantis is building three gigafactories, one in Italy, one in France and one in Germany, by the joint venture with Total Energy and Mercedes-Ben. The gigafactory in France has been inaugurated in Billy-Berclau Douvrain in France the 30th of May 2023. More details can be found here.

visible.

Given the status of the sector, the institutional response in Italy emerges as weak and not timely. A Board of coordination between social actors and the national government ("Tavolo Sviluppo automotive") to increase the competitiveness of the sector was established only in November 2023 according to ANFIA (Associazione Nazionale Filiera Industria Automobilistica). In the meanwhile, trade unions have requested for a comprehensive industrial policy plan on public and ecological mobility since 2020.[7] However, so far, a coordinated social dialogue institutional setting is missing, with scattered and non-coordinated initiatives proposed by the single actors, without a clear coordinated plan to face the current process of digitalization/automation and decarbonization of the automotive industry.

Policy interventions for the decarbonization process of the automotive sector have been targeting the transition only by tax exemptions and purchasing bonuses,[8] other than the implementation of European regulations about charging infrastructures and of the NRRP objectives. The Italian NRRP allocates €740 million to reach the goal of 31,500 public fast-charging points by 2030 (and 6 million electric vehicles), 3,64 billion for the renewal of bus fleets and green trains. However, the NRRP does not envisage ad-hoc policies to guide the development of the technological and organisational transformation of the automotive sector, nor to tackle the employment effects of the transition. A timid switch to hybrid and electric productions is coupled by the request for voluntary redundancies of Stellantis and even closure of many plants in the supply chains, as in the case of Magneti Marelli in Emilia Romagna (Cetrulo et al. (2023)).

In 2022, the law (legge n.34/2022) "DL Energia" has activated the "Automotive Fund 2022-2030", allocating 8.7 billion until 2030 – 650 million in 2022-2024, 1 billion each year from 2023 and 2030, for purchasing bonuses and investments for the development of an innovative and sustainable automotive production. In particular, 50 million in 2022 e 350 million euro each year from 2023 to 2030 are allocated for the 70% for the "Development Contracts (Contratti di sviluppo) and for the 30% for "Innovation Agreements" (Accordi per l'innovazione) for the transition of the automotive sector.

A broader plan for decarbonization is the National Integrated Plan on Energy and Climate (PNIEC) which will be approved by June 2024. The plan has been elaborated by the Ministry of the Economic Development, the Ministry of Environment and Land and Sea Protection and the Ministry of Infrastructure and Transport and it envisages the reduction of emissions in non Emission and Trade System sectors by 43,7% by 2030 with respect to 2005; energy efficiency and security by the diversification of supply sources and optimization of infrastructures and natural gas production; the empowerment of the internal energy market (electricity interconnection) and investment in research and innovation to increase the national competitiveness. However, the plan lacks long-term measures to reach these goals, still relying on natural gas according to environmental associations.

Other policies in place relate to hydrogen strategy, both financed via the NRRP resources (as the conver-

[7] National event organized by metalworkers trade union to discuss the future of the automotive sector in 2020 here.

[8] Details can be found in IEA: Green mobility bonus; Ecobonus: Subsidy for low-emission vehicles; Bonus-Malus

sion of disused industrial areas into hydrogen hubs) and different alternative funding. In 2023 the Ministry of Transport allocated 24 million for the acquisition of hydrogen power trains and 276 million euros for the establishment of at least 10 plants for the refuelling of hydrogen along at least six rail lines by 2026 (Source IEA). Investments at the current stage still have to materialise.

3 Research questions and methodology

The qualitative analysis allows the effects of the electrification strategy on work and organisational dynamics to be captured.

3.1 Case selection strategy

The selection strategy bases on the identification of plants located in an homogeneous geographical area characterized by process of transition toward the electrification. Both cases are component production facilities located in Tuscany. Despite various changes of ownership, both factories have a long history in the industrial production fabric of the area, a location considered strategic and high-value given the endowment of skills and know-how. This also linked to the presence of universities and established automotive incumbents on the market. Both facilities are in fact characterised by a strong attitude in innovative activities, in particular by a remarkable push for digitisation and automation. Currently, both facilities are owned by foreign multinational companies. They are both suppliers of parts and components for European and non-European OEMs and both plants are of medium to large size. In addition, they are also under the same trade union. In what follows we provide for the story of each plant. A brief summary of the level of automation and digitisation and the effects of the decarbonisation strategy will be discussed. Such extended introduction has the aim to provide for a complete frame of each case before delving into the firm patterns' analysis showed in the next Section and workplace results about GVC restructuring, MNC relationships and capabilities to respond to crises discussed in Section 4.

Case I - A case of tentative transition

Case I is a manufacturer of pumps and depressors for power breaks. It is an historical plant of the area, founded in the 1930s, that came under the current ownership of a foreign MNC in the early 2000s. The current owner is producing both for the defence and the civilian industry, mainly for the automotive. The new owner wanted to buy the plant as holder of a specific patent, with the intention to close the plant soon after. Thanks to the efforts of the trade union and of a manager, already manager of another Italian plant of the group and put in temporary charge of this facility, the plant wasn't closed. The closure was avoided at the cost of 300 pre-retirements, that reduced the workforce from 550 to 250 workers, which is still the current size. The fact that the plant was characterised by a high level R&D department, thanks to the high value location and the long time cumulated knowledge, hindered the choice to close the plant. The innovation

capabilities in developing new products maintained the level of competitiveness high with respect to other firms but also to other plants within the group.

Among the 250 workers, 120 are blue collars and about 20 of them are precarious with staff leasing contracts. The plant is characterised by a high level of trade union membership, with around 75 blue-collar workers and a few white collars (about 10-20 members). At the plant level, the bargaining power of workers representatives is quite high, they achieved to close some agreements with the management about limitations in the use of digital instruments that could have been used to control workers. The plant works in continuous cycle on three-eight hour shifts. The plant is quite big, with 9 conventional production lines and one line for the production of the electric pump. There are no more than 1 or 2 workers on each line. Level of automation is high, robots are mainly anthropomorphic arms, AGVs are also present. The first robots were introduced in the 1980s and 1990s during the first wave of automation, in 2017 a new line was introduced with Industry 4.0 investments. The one for the production of the electric pump introduced in 2020 is the most recent. In general, there are no wide process innovations in the plant since production lines are flexible and modular, they can be adapted and integrated to the production of new products. Innovation focuses on product innovation, usually customized on clients' requests. The upgrading of digitalization of production is work in progress. The digitalization has been upgraded to integrate the systems within the group, by a software developed internally from a firm located in Germany, even if it is not a Manufacturing Execution System (MES) since it doesn't programme the production but it only reports data for the quantity and quality of the produced pieces ex-post. However, the digital system does not register directly the data into the plant administrative system (SAP); the operators still need to register them manually from each workstation.

The electrification process concentrates in the production of an electric pump, a component used in electric vehicles to lubrication and cooling of the electric drive motor, the batteries and/or the gearboxes. The firm started with a small production of electric pumps in 2013, to already enter the market of electric vehicles. In the electric pump, the circuit board and the electronics substitute the mechanical mechanisms of the mechanical pump. This does not translate in a shorter production line. On the contrary, there is an additional worker to set the rotator externally to the line. For the assembly instead there is the same number of operators as for the assembly of other products, and the operations of the workers are not that different. Other aspects of the effect on blue-collar workers is provided in Table 3.1, while details about transformation at the high skills level are discussed in Section 4. The production of the electric pump has not lead to a higher degree of complexity of the production process. Notwithstanding, the emerging complexity derives more from the organizational side due to product specificities (see Table 3.1 for further details).

The process of decarbonization embraces also energy and water management to be carbon neutral by 2035. At the production level the plant should shift from natural gas to electric foundries, but no intervention has been made since it is economically unfeasible. To save on energy costs, the plant had already started adopting monitoring systems and measures for efficiency use of resources. The main driver of adopting energy management strategies is being part of an MNC that is a publicly listed company. The company

needs to be compliant to ESG requisites, especially since other automotive companies need to and not being compliant translates to loose business; good ESG ratings are also necessary to attract and obtain financial funds. Examples of interventions are provide in Table 3.1 as effects on work.

We define this case as a case of tentative transition. Although the plant entered the electric vehicle market with the production of an electric pump, the low production volumes compared to non-electrified products, the missing role of the plant in the high-value (R&D) part of electric pump development, and the loss of specialization and autonomy due to market transformations are all factors that are leading to an increasingly marginal role of the plant within the group and the value chain and prevent the plant from being a successful transition case. All these aspects are developed in Section 4.

DECARBONIZATION - *tentative transition*

Process	Product	Energy Management
1. New production line has been installed: • need for clean and careful environment to handle the circuit board and small components: isolated "grey" room to avoid contamination from the rest of production; • electrostatic environment; • no particular process innovation: ordinary lines are usually constituted by 20 processes, the electric one has added between 5% and 10% of processes; • tighter production with respect to other productions because it is smaller, takt time of 23 seconds; • the circuit board is provided by a European supplier. 2. Effects on workers: • same number of operators as on the other lines for the assembly, additional operator for operations before the assembly; • No safety risks emerge from the interviews.	1. Production of the electric pump: • started in 2013 with a small production; second big business in 2016; currently 6 booked businesses; • The electric pump is the outcome of the electrification of production, not of the product innovation of pumps in general; • Questionable sustainability of the life cycle of the product: it is mainly made in plastic that is welded, thus no intervention can be made on wastes; • The electric pump will not substitute the mechanical one: even for ICEs, hybrid and other services an electric pump can be used, however the cost of an electric pump is at least 50% higher than the mechanic one. 2. Effects on workers: • no specific training, only for electrostatic safety; • hiring of just one technologist, no specialized operators have been hired.	1. Monitoring and efficient use of resources: • monitoring systems account for the use of energy; • use of the waste heat from the compressors -about 75% of the energy input- as heat for the workshop; • use of solar energy allows to storage energy for 50% of the daytime; • to some extent digitalization is meeting decarbonization in managing the carbon footprint of the plant (software to automize carbon accounting). 2. Effects on workers: • creation of the Environmental Social Governance Manager as a new figure and of the Energy Manager as a new role (covered by the maintenance supervisor, not a new figure); • no direct operation effect on the productive process is expected on workers. • possible indirect effect of savings in energy costs transferred on operative costs to generate more labour in the long run.

Case II- A case of failed transition

Case study II refers to a spin-off (established in 2019) of a multinational company involved in the production of several parts and components for the automotive industry. The young spin-off develops and produces injectors for ICEs and it is one of the main suppliers of the key European and non European OEMs. The history of this firm goes back to 1987, when a large MNC established an R&D lab for the development of an electro-injector in Tuscany. The production started in 1992. In 2009 the firm was acquired by the new MNC. This facility has just overcome a crisis period begun with the announcement in 2019 of the electrification strategy and a redundancy plan for 750 employees over the entire workforce of around 1000 workers in the following few years. It was part of the plan of closure of all subsidiaries active in the combustion industry, envisaging 30,000 potential redundancies overall. The selected case is in fact an archetypal example of how manufacturing activities are and will be severely affected by the decarbonization process when producing components for ICEs that do not enter the composition of electric engines.

The firm is newly part of a MNC group developing and producing components for the ICEs, electric vehicles and hydrogen power-train solutions. The new ownership has bought the plants to manufacture injectors for internal combustion engines since this trajectory is expected to coexist with the decarbonized ones in the next future. The firm will supply injectors especially for non European markets and it has started to develop injectors for hydrogen and other e-fuels vehicles. We define this case a case of failed transition. Hydrogen and e-fuels are not the main solutions for decarbonization defined by the policy and the market push, while electrification is, and despite the availability of skills and the several efforts of the R&D department to convert the production, the strategy of the new ownership has prevented the development of this path for the plants. Further details are discussed in Section 4.

The firm has about one thousand employees, a small percentage of which are precarious and are used by the company to respond to peaks in demand. The firm is characterised by a low turnover (1%) and of positive synergy with the territory, as collaboration with other local firms about for R%D, electrification or hydrogen solutions; and with Regional institutions. The Regional government seems to have played an important role during the transition phase towards the new ownership to avoid 750 redundancies. Union members are well over the 40% of the entire workforce.

The plant works in continuous cycle, three shifts of 480 minutes, only for some products production may stop. The production lines are highly automated, cobots and AGVs have been introduced with the Industry 4.0 investments in 2017. The plant is characterized by a high degree of digitalization of production as well, having the Manufacturing Execution System active since at least 30 years. Product innovation drives process complexity and changes in work organization. A key trend has been the Industry 4.0 (I4.0) strategy, conceived as a way to organize production after having it digitalized, data collected from digitalization mechanisms signal if and how a production process may be automated. The digital and automation processes are considered as necessary to keep the competitiveness high by the optimization of processes, competitiveness also with other sister companies, to avoid the risk of relocation.

DECARBONIZATION - *failed transition*

Attempts under the past ownership	Activities under the current ownership
• Voluntary training on electrification of a group of R&D engineers at the University of the area, training project with the partnership of the Regional government; • Development an electric engine "in secret" from the company; • Partnership with a local firm developing and producing electrolysers; • Disclosure after 6 months to the company about what they have learned and developed. The company invested 3 million euro on the project, but this didn't prevented the company to sell the plants to the new owner.	• Electrification is not the decarbonization strategy of the company: – Production of ICE injectors, the original business; – Despite the availability of skills in electrification, R&D is focusing on hydrogen and e-fuels solutions.

3.2 Firms' patterns

In this section, we provide descriptive statistics on the patenting activity and economic-financial information of the observed companies. In particular, figure 3.2 shows the time series (from 1975 to 2022) of the innovative activity of the two corporations.[9] The brown curve represents all patents filed by the company, while the green curve refers exclusively to electrification technologies. The latter were identified by leveraging the CPC codes. In other words, we highlighted the dynamics of patents with CPC equal to Y02, i.e "technologies or applications for mitigation or adaptation against climate change". Case I shows a more modest and rather stable innovation dynamic over the period considered (with more than 36 patents/year). Excluding the two peaks in 2007 and 2015, this innovation dynamic applies to the entire patent bundle as well as to decarbonisation technologies. In contrast, the second company has a more markedly positive trend, going from just under a hundred patents in the late 1990s to over 350 in 2021 with a peak of 528 patents in 2017. This growing dynamic also relates to knowledge about decarbonisation technologies, which is reflected in the trend of patent activity in green.

Figure 2, on the other hand, contains information on the economic and financial characteristics of the two companies for the period 2014-2023.[10] As we see in panel (a), the level of employment (without taking into account contract, temporary or staff leasing workers) is decreasing in both cases: case I from 430 employees in 2014 to 380 in 2023, and case II from 940 in 2019 to 860 in 2023. In both cases the uncertainties related to the future of the plants in the transition are complicit in the reduction of the workforce (as we will see in more detail from the results of the field analysis). The employment situation in case II is also aggravated by the company crisis that led to voluntary departures resolved with the arrival of the new ownership structure in 2019. In panel (b) we see the overall value of wages (thousands as units) slightly decreasing and in line with employment dynamics. The level of sales and profitability (EBITDA) can be observed in panel (c) and (d) respectively. They show a stable and slightly decreasing trend over the reference period: in case I the reduction in sales starts in 2018 and recovers after the Covid-19 pandemic, while in case II the decrease in sales is concomitant to the corporate restructuring. Panel (e) finally shows the value of intangible assets.

[9] It should be noted that the information available on Orbis-IP refers to the patenting activity held at headquarters (relative to the entire multinational structure) and not specifically to the two visited facilities. Nevertheless, it seems relevant to us to contextualise the *tentative* or *failed* decarbonisation process in the light of the technological knowledge developed in the respective organisational context.

[10] In this case, Orbis BvD provides us with data on the company structure at the Italian level. In addition, with respect to case II, we have information for the four-year period following the 2019-2022 acquisition, as that for the previous company is no longer available.

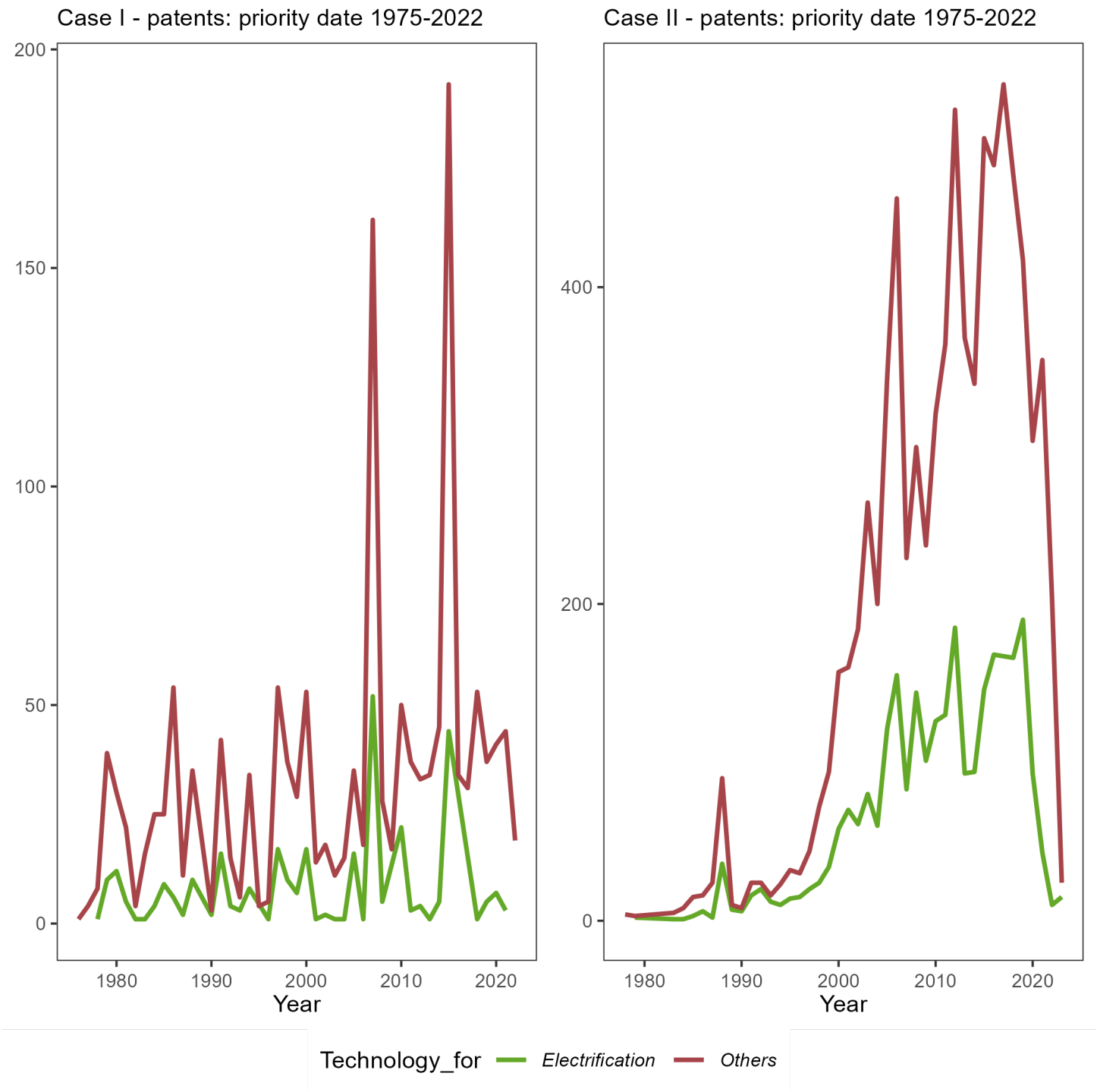

Figure 1: *Electrification* refers to patents with 3-digit CPC equal to $Y02$. *Source:* Orbis-IP, authors' elaboration

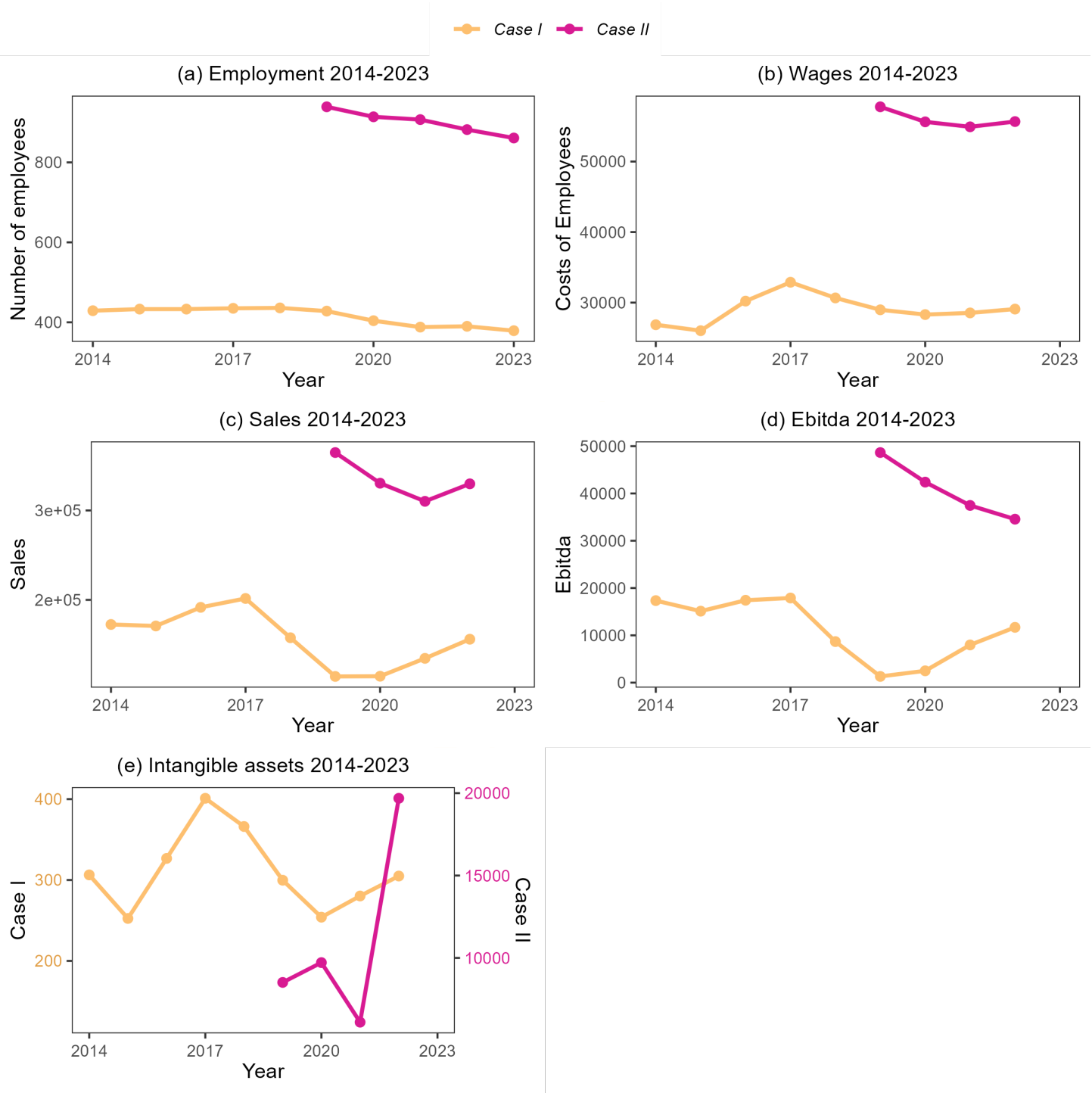

Figure 2: *Source:* Orbis BvD, authors' elaboration

4 Workplace analysis

In what follows we provide for the main evidence from the workplace analysis. In particular, we focus on the effects of decarbonization on three aspects: (i) the restructuring of the GVC, the mechanisms why there has been a repositioning of the plant consequent to decarbonization strategies and market transformations (ii) the repositioning within the group and the relationship with the mother company with respect to decision making and crisis' management; (iii) the ability and capabilities of workers and their representatives to respond to transformations due to the decarbonization, company crises and change in ownership structure.

4.1 A case of tentative transition

Case I can be defined as a tentative case of transition. The main change is constituted by the production of the electric pump (details are provided in Section 3.1 and Table 3.1). However, there are several aspects that suggests the transition to be tentative and not successful and complete: (i) the volumes of production of the electric pump are still marginal with respect to the other products -1/10 per day with respect to their core production of variable oil pump-; (ii) despite the automotive sector is still the major target industry of the business, the plant is producing also pumps for other industries, as heating systems; (iii) the plant is not core for the development of the electric products and is dependent from other sister companies of the group where core competences for the electrification are located; (iv) there is no willingness from the headquarter to invest more in the plant towards the electrification strategy, suggesting a gradual shift to a more peripheral role of the facility within the group. Nonetheless, it is a competence centre for the development of mechanical pumps; (v) workers are feeling a high level of uncertainty about the future of the plant related to the shift to electrification, suggesting an unclear strategy on the part of the company in the long run: respondents are in fact concerned about how the plant will be able to keep up with other competitors in the market, as it is still heavily dependent on the ICE market in terms of production volumes and know-how. Overall, growth in demand for the electric pump is expected, but currently, there is high uncertainty of the direction that the automotive sector will undertake despite the European Union is pushing on electric vehicles. We delve into each of these aspects in what follows by providing some extractions from the interviews as well.

4.1.1 GVC restructuring

Case 1 is an example of GVC reconfiguration: from being a Tier 1, the plant has shifted to Tier 2 in many businesses. The head project acquisition and product strategy manager clearly states:

"The difference from the past is that in the past I had to deal only with [name of some OEMs], with all car makers. Now the market has changed: we don't have to go only to them, but also to them. There is a new market with a lot of start ups -you can see in California there are several producers of electric vehicles, maybe with lower volumes- and they are new clients. Sometimes, we have become from Tier 1, from dealing directly with the car makers, to Tier 2.[...] [A car maker] buys the powerTrain, the electric drive unit [from another Tier 1] who buys from us, while in the past I sold the pump directly to [the car maker] since it produced its own internal combustion engine internally. While now clients buy powerTrains and electric drive units externally and we become Tier 2."

The interviewee also confirms that positioning is contextual to the electrification of production. The market is changing because of an increasing number of competitors entering the market -as start ups for electric vehicles or manufacturers starting

to produce new components-, and OEMs are buying components from Tiers 1 to a greater extent than when producing internal combustion engine vehicles. Internal combustion engines were mainly developed and produced in house by OEMs, while now OEMs buy electric drive units from Tier 1, implying that Tier 1 now may supply to other Tier 1, becoming Tier 2. This reconfiguration implies an additional mechanism of dependency from another intermediary, the Tier 1, also with respect to business opportunities, previously handled directly as Tier. This implies for the R&D department to widen its network and to take care of the relationships with other Tier 1.

The plant is loosing specialization and autonomy, becoming also more peripheral in the GVC of the sector. Although the plant is a core facility for the development of mechanical pumps because of the skills and capabilities of the R&D department, they have not been translated for the development of electric pumps. Skills in electric and electronics engineering are needed and lacking in the plant (this is a common aspect emerging in several interviews). Centres for the development of electric pumps are located in another plants of the group where electric engines are developed as well. The development phase occurs particularly in Germany, core country of the European automotive sector but also in France and in another facility in Italy. The company has decided to concentrate electronics and electric engineering in a new R&D centre in Italy instead of investing in the existent plant, despite the plant is in continuous contact with local universities in which the requested competences could have been found and training for engineers in electric and electronics could have been provided. The R&D department has been marginally trained thanks to the push of the R&D manager, but only to ease the exchange with other competence centres. This undermines the core characterization of the plant we are considering.

Another aspect that is challenging the core positioning of the plant is the increasingly degree of competitiveness among the sister companies for businesses to be assigned and the bargaining power of the plant with respect to the headquarters decisions. We delve into this aspect in the next subsection that explores the relationship between the case under study with MNC.

4.1.2 Relationship inside MNC

There is a strong competition among the sister firms within the group for the allocation of the contracts of production obtained by the parent company. This put the plant under study in a difficult position for two reasons (as declared by a trade unionist). Firstly, since it is located in Italy, where labour costs are high and the group is pursuing a cost-competitiveness policy among the different child companies. Some workers' representatives define the market as increasingly *"wild"*:

you're always competing and you're always looking for a new business. When they (the company) assign it to you they say I come to the plant, you show me the development, how are you going to make this product and at what cost? And they create a cost competitiveness with other plants, saying make it for me at 10, can you make it for me at 9? A mechanism is triggered where you have to be ready to make this product already, that's why it's good for us to have prototypes that we have in our plant, because that helps us. But it's clear that it's a mechanism that in the end is a downward auction. In Italy a worker has an average cost of 35-39 euros, you account for transportation, the product, at the current state we are not one of the countries where they made the investment very willingly. What do you have to play on? On product quality, on product development and waste, and on trying to produce one more than the others.

Secondly, the complete shift to the production of the electric pump and the lack of other productions would imply the risk of high number of redundancies since the electric pumps are 90% made of plastic and all the mechanical processes of welding would be not needed anymore, reflected in a lower need for workers. With this respect, maintaining the level of

competitiveness high has been a key strategy of the MNC during the transformation of the plant, also by reducing the level of operators on the line. The same interviewee told us that at equal, if not higher, level of automation of other plants in the area, the workforce in their plant has been reduced much more during the change in ownership. This choice has been a strategic outcome of the firm to renovate the plant by a big investments in machines and make the plant more competitive also within the group with respect to those sister companies in parts of the world where the cost of labour is particularly low.

In addition, among the criteria of assignment of production of each product, the company considers the industrial relations and the probability of strikes and conflicts with workers and trade union, discouraging such practices.

The interview with a workers' representative of the plant that covers the role of vice president of the European Work Council (EWC)[11], a meeting occurring 5-6 times a year where workers' representatives are informed by the company headquarters about corporate strategies and investments, revealed that during the last EWC the company representatives had confirmed the rumour the company was opening five plants in Hungary (three for the defence sector, two for the civilian industry) where to produce the hydrogen technology. The attempt to bargain about locating the production of the hydrogen technology in the plant in Tuscany was useless. The Hungarian government has allocated a non-repayable fund of 65 million euros other than investing in the construction of the five plants, bound to the request to the company to assign the production of hydrogen technologies in those plants. The public intervention played as a key element for the decision of the headquarters where to allocate the production of specific products, factor that as explained in Section 2.2 is lacking in the Italian context. In addition, Hungary falls into what Pavlínek (2022) defines as "integrated periphery" that offers cost advantages for companies. It is often characterised by low labour costs, geographical proximity to large markets, a high-quality of infrastructure and logistics development, membership in regional trade agreements, investment incentives and low corporate taxes (see Section 2, Pavlínek (2022)).

Hydrogen technologies are not residual in the strategy of decarbonization of the company, rather the most important. The interviewee declared that the company does not discuss much the electrification strategy since it does not believe in this technological solution, rather it develops electrified products to fulfil OEMs requests driven by the policy boundaries. The company in fact is mainly researching in hydrogen solutions. It emerged also that the company is not interested in investing in the plant under study for the decarbonization process:

"no, [in our plant] we do not do nothing about hydrogen. The R&D is the main centre for the pump division. Everything that is a pump, VOP or classic, goes through [our plant]. Then it is assisted by the R&D from [a plant] in France or in China, but everything passes by [our plant]. Anything that does not concerns pumps, the head office is the plant in [...] in Germany.

and when discussing with the company representatives the possibilities to allocate the production of hydrogen technologies in the plant

I have made such a question (to bring hydrogen solutions production to the plant) in the meeting of June. The answer has been that [our plant] is the leader in R&D for mechanical pumps and will remain as such".

Such evidence suggests a high risk of a progressive confinement of the plant to a peripheral role within the group. The attempt to bargain the allocation of hydrogen technologies production in the plant under study reveals a proactive role of the

[11]Established under the European Directive 2009/38/EU, the European Work Councils are envisaged for in companies or groups of companies with at least 1000 employees in the EU. Further information about European Work Councils can be found here.

workers' representatives. In the next paragraph we discuss the ability to respond to changes from decarbonization strategies and the internal capabilities of this case of tentative transition.

4.1.3 Ability to respond

The interviews reveal a behavior of responsiveness of the workers to the changes in production and to the corporation's strategy for electrification. According to the workers and representatives, the outlook for the medium term is unclear, and they express a strong feeling of concern about the future of the plant. The head of Business Excellence to the question whether there are exchanges among blue and white collar workers and workers' representatives about the future of the firm answered:

Yes there are times when all operators and employees want to understand where we are going, to understand this future. We are going towards a forced electrification, you see the lines are more and more automated, there is a high uncertainty to understand the future of the company. You see even a company like [name of a competitor] that from the automotive point of view could not make an engine, but if you tell them make me an electric motor, they start to have something to say. Electrification is leading us to ask a main question: Can we keep up with it? We are trapped with endothermic engines... Have you ever had the experience of opening a hood of an electric car? There is nothing inside.

The uncertainty of the workers with respect to whether the plant will be able to keep the pace of the transformations, also with respect to other big competitors, reveals a strong awareness about the factors at stake and the possible transformations and implications on the survival of the plant and workforce. At the same time, it is another signal of the fact that the plant is not core for the electrification. The plant is not conveying a clear strategy, suggesting a loss of decision-making autonomy and an increasing dependency on corporate strategies that are confining the plant to a peripheral position within the group and, consequently, in the automotive industry in general. In fact, there is not a proactive response from the R&D department to find alternative solutions, except of producing mechanical pumps for heating systems. However, that strategy would imply to partially exit the automotive sector and it would translate in a downgrading for the plant. Case I has not put effort in improving skills and products' upgrading to signal responsiveness to the company. The role of the plant has been quite referential to the strategic choices of the company, possibly for a matter of resources as well. The head of the R&D department has appointed that only basic training for the R&D employees has been provided in electric and electronics, but that professional profiles with specific skills are needed, but missing. Skills adaptation is one of the key organizational capabilities to cope with changes in technical regimes. The head of project acquisition and product strategy to the question asking whether they have lost autonomy and specialization due to the shift to a Tier 2 positioning in many businesses answered:

Absolutely, because we depend more on the parent company. We as R&D, this a criticism that has also been made to us, should not wait for a product from heaven, that is, for Germany to tell us that we have to make this product. It is obvious that as R&D we have to come up with something. But it is also true that out of nowhere, we cannot invent a valve to clean the sensors of the machines, because it depends on the parent company, if it gives us the okay to work on that product.

What emerges is that Case I lacks of the capabilities to manage unpredictable patterns of behavior, the promptness to react to an increasingly subordinate positioning. Differently, workers' representatives have been proactive in bargaining the allocation of production of hydrogen technologies, even if failing, as they played an important role in preventing the

closure of the plant during the change in ownership in the 2000s, stressing especially on the high skills and value of the R&D department.

We will see that Case II (even if the attempt of transition has completely failed) is characterized by established organizational routines of strong adaptation, to stay competitive and improve probability of survival.

4.2 A case of failed transition

Case II is a case of failed transition. The plants were left out from the conversion to electrification of the past ownership. The new ownership, a group developing power train technologies, both for electric and hydrogen solutions, has bought the plants to keep the manufacturing of injectors for internal combustion engines, since the two trajectories are expected to coexist in the next future. Keeping production on two parallel trajectories will enable outlets to be found both in the European market (with the production of components for the electric power train) and in markets where legislation on co2 emission limits does not yet apply. The firm is also developing a prototype of an injector for hydrogen; finally, it is willing to research about engine components for hydrogen and alternative fuels, accessing ministerial funds (e.g. in relation to National Recovery Plan and Regional resources).

4.2.1 GVC restructuring

Differently from Case I, this case has not been subject to repositioning on the value chain. Directly, because of the lack of conversion of the production. The plants are still producing and supplying injectors for ICEs as Tier 1 suppliers. On the other hand, the plants are subject to a reconfiguration of the value chain of the automotive sector in terms of core vs peripheral positioning. The plants had a core positioning thanks to their high level of skills and capabilities; established routines of continuous improvement in technological innovation keeping high the level of competitiveness; various partnerships with local Universities, other firms, Regional and local government. Nevertheless, the past ownership first and the new ownership after have started a progressive relegation to a peripheral role of the plants within the transformations of decarbonization. Firstly, the plants were left out from the choice of which firms within the group to convert for electrification, despite the fact that the factories responded promptly to show that they would also be able to be part of electrification (we delve into this aspects later in the section); secondly, the new ownership bought the plants to have a unit to produce for the ICE segment of the market, while other centres within the group are core for the development and production of hydrogen and e-fuels components. The Head of Production stated:

Now we go into a company where there are three main centres: the first derived from an engine development centre that has already begun to invest in the path related to the development of engines with alternative fuels, so hydrogen in particular. There is another manufacturing location that makes transmissions that will have little to do with us. [...] They are verticalizing with our purchase so that they have ownership of everything that is the strategic and fundamental part for new resolutions. [...] We support heavily what concerns in the diesel area all the part of the treatment of emissions, the part of urea injection in the exhaust pipes [...] The diesel engine is an area that has considerable development [...].

The firm is proposing R&D projects on alternative technological solutions as hydrogen injectors and hydrogen engines. Nevertheless, it comes from an internal push of the firm thanks to specific capabilities of the organization. We delve into this aspect later in the section. The first strategy of the company is to keep the plants in the ICE segment, this is the main reason

why they have bought the plants in the first place. There is thus the risk of a progressive confinement to a peripheral role in the automotive sector since it is left out from the key decarbonization strategies. In addition, the company is investing in hydrogen solutions and not in the electrification that is the current key direction of the market.

4.2.2 Relationship inside the MNC

As introduced in the case description in Section 3.1, Case II has undergone a deep crisis when the previous ownership declared during the European Work Council of 2019 the plan for the next 10 years that entailed 30,000 redundancies concentrated mostly in Europe in all facilities related to the internal combustion engine segment. The crisis for the Tuscan facilities ended with the purchase of a new buyer. We can't provide for specific information of the relationship with the new ownership of the plants since the interviews were made before the transfer was completed. However, the interviewees expected the relation to be different since the group is smaller and its an entrepreneurial entity rather than a big multinational company. Competition with the other plants about assignments of production is not in place since the plants are the only ones producing injectors for ICEs. Nevertheless, since the acquisition has been pursued to keep the original business of injectors for ICEs and the competence center on RD on alternative solutions is located elsewhere, this may suggest a progressive departure of the plant from the decision-making center for Case II as well. We report some information about the relation with the previous ownership that may provide useful insights to understand how the process of decarbonization was managed by a MNC.

When under the previous ownership, Case II was instead in a tense internal competitiveness with its sister companies. As experienced by Case I as well, the MNC acted by progressively moving away the decision-making center from the plants by a gradual delocalization, exploiting the transition by changing allocating development and production projects in other facilities, shifting from the core to the peripheral positioning of plants. One of the members of the EWC of the company revealed the decarbonization to be exploited as a relocation strategy:

the offshoring strategy had happened years earlier (with respect to the declared redundancies in 2019) with a new way of offshoring. That is, I no longer shut down a plant and move your production elsewhere, but I let you get on with yours, but the new projects, the new things start making them from scratch elsewhere. That way that they relocate: so no longer with all the negative publicity of the struggles, the burned rims, the hard struggle and the unemployment overnight, but slowly, with the transition [...].

Common practices of relocation were also occurring. The parent company started to move the production of components close to OEMs assembly plants build in low cost - mainly Eastern European- countries. The introduction of cobots in the plants in Tuscany reduced production costs and has hampered the delocalization of the production in the fuel rail department characterised by a high degree of manual work. It was actually meant to be delocalized in the Czech Republic, closer to the OEMs and with lower labour and production costs. Differently, one plant in Spain, was closed after two years for relocation in Hungary; an other plant that was not even written in the entire redundancy plan was also closed (from the interview with the EWC member, *"the delegate wished me well when they declared we were under redundancy at the European Work Council in 2019. Two months later she told me they would have produced only for other two years and then the production would have been located in Hungary, where the digital dashboards were produced."*).

Not only several plants that were not included in the redundancy and in the conversion plan were closed, but even some of the plants which were converted to produce for the electric market. The latter were closed because the company had made too large an investment compared to market requirements.

Already before the disclosure of the redundancies of the previous ownership, the management of the plants and the trade unions had agreed on a reindustrialization plan to convert the plants towards the industrialization of electric and hydrogen components. In 2019, after the announcement of 750 redundancies, the agreement became a protocol signed with the Regional government. Actually, the operational manager of the company found a possible agreement with a local firm to produce electrolysers. Nevertheless, the plants were not included in the conversion plan. The management and the trade unionists pushed to keep this protocol with the Regional government under the new ownership as well. We do not have the information whether the protocol will actually be applied under the new ownership yet.

4.2.3 Ability to respond

Case II can be seen as a textbook example of a problem solving entity with cognitive and operational knowledge. This is reflected in the ability to interpret external changes in the environment and to adapt to changes in technological regimes by having repeated and established basic routines. The firm is in fact an exemplary case of active response of the workers to the effects of decarbonization and, specifically for these plants, to the firm crisis derived from the electrification strategy of the past ownership. Nevertheless, it is a case of failed transition. After the declaration of dismissals in 2019 due to the electrification strategy of the parent company, the management of the local firm tried to avoid the closure of the plant by showing they were able to face the new challenge of electrification. They showed interest and willingness to switch from the production of injectors for internal combustion engines to electric components. As stated by the HR manager, both the management and workers were aligned on the desire to "make themselves indispensable" for the parent company. In her words:

"without us being invited by the corporate, we do projects within the community, we are really on top of so many technologies because you have to make yourself indispensable"

15 engineers of the R&D department had voluntary participated to a training project about electrification provided by the local University in partnership with the Regional government. Being all mechanic and aeronautic engineers they didn't have the skills about electrification. They started developing an electric engine and inverters by their own, they started a collaboration with a local firm producing electrolysers, they produced a prototype of an axial flux motor and the parent company financed the project, which was interrupted by the new acquisition. The head of the R&D department told us the story:[12]

"In this advanced course on electrification, the professors were explaining a type of engine and we were looking at each other saying 'we have never heard of this engine; how come we don't have it?' and finally we decided in a pioneering way to try to develop it. After six months of activity, we told the company what we had learned and why they didn't have this product, as it has many advantages. It came out a "ruckus", let's say we gave a snub to experts on these issues, proposing something new and it raised so much interest that the company gave us 3 million euros to develop this product here, so for three years we have been working on this issue. We made the first prototype, after nine months we already had a prototype in hand when, let's say, typically our colleagues in Germany take twice as long. We generated so much interest, with less time, less cost, and we produced concrete results, in the end we gained credibility again even in this area they entrusted us with 2 to 3 million to develop this product that basically stopped this summer with the transition to the new ownership."

[12] At the moment of the interview, the plants were not under the new ownership and the head of R&D thought that future developments of the project may have been possible with the new ownership, despite the group is concentrating R&D activities on hydrogen and e-fuels technologies.

The established routine of continuous improvement is applying also with the new ownership. Although the plants have been bought to produce for the ICE segment and another firm within the group is the core centre for the development of alternative solutions as hydrogen, they are proposing prototypes of injectors and hydrogen engines. The Head of production stated:

We are working on a road map that, precisely we will still have to confront a little bit to confirm its sustainability, but we would like from next year to have the first working prototype of hydrogen injector [...]. We are discussing with the ownership because we will need to present a project that concerns not only the injector, but also the engine part related to hydrogen or in any case related to the use of alternative fuels to fossil fuels, and on this we believe that we can access precisely projects among the so-called "development contracts" that within the ministry are established and granted if the project can be of interest.

This active role and response stands in contrast with the strategy of the firm to concentrate R&D on hydrogen and alternative solutions in another firm of the group.

The high level of capabilities and specific routines distinguish this case as a core facility of the area. Nevertheless, changes due to decarbonisation has contributed to the loss of centrality and relevance of the Tuscan facilities. First, the announcement of the redundancies predicted a conspicuous downsizing of the Tuscan site. Then, with the takeover by the new owners, the intention to confine the plant to a marginal role within the group was once again noted.

5 Discussion

We briefly summarise the common findings between the two cases with respect to the firms' patterns descriptive analysis and the effects of decarbonization on (i) the repositioning and restructuring of the GVC within the Italian automotive sector; (ii) the relationship within the MNC and with respect to the transformations of the market; (iii) the ability of workers to respond to the current transformations. The shared aspects may be resumed as follows:

1. descriptive evidence shows the two cases to be comparable with respect to firms' patterns at the company level: employment is slightly decreasing, wages are quite stable -the companies are under the same contractual national agreement-; sales are increasing in the last years after a common decreasing trend between 2019 and 2021;

2. although both are characterised by a core positioning in terms of skills and innovation capacity, partly due to their location in a high-value specialisation area, this peculiarity is not reflected in the way the two are coping with decarbonisation. Both are undergoing a progressive repositioning towards a peripheral role within the groups and in the market. Neither is a centre of competence for the development of technological solutions for electrification or hydrogen;

3. both are subject to an increasing level of competitiveness on the market also with respect to firms within the same group. The MNCs are commonly distancing the decision-making center from these plants, end up being more deferential to the companies' strategic choices and lose their autonomy;

4. workers have both an active role and attitude to cope with the transformations at stake and to respond to firm crisis. Both cases have in fact undergone a threat of closure.

With particular reference to the first case, the shift from Tier 1 to Tier 2 reflects the retreat into a more marginal position. As emerges from various interviews, the mere process of grabbing business proves to be more difficult and makes the production activity more dependent on the production choices of other players.

Finally, it seems interesting to us to systematise the information we have gathered on the two plans of analysis presented. With reference to patenting activity, we have found that Case I of tentative transition presents a more modest innovative capacity, especially with respect to transition technologies. On the other hand, the innovative capacity of Case II paints a picture of an advanced company ready to develop the knowledge necessary for electrification. This is reflected also on the capabilities of the firm showed in response to cope with the risk of relocation of production and of redundancies for Case II, differently from Case I that shows a less proactive role from the organizational routines' perspective. Also the levels and the evolution in intangible assets provides for a similar picture (Figure **??**). Nonetheless, Case II is experiencing a decreasing trend since 2019 in profitability, differently from Case I (evidence from Ebitda in Figure **??**).

6 Conclusions

This paper has the aim to understand how the decarbonization impacts on GVC restructuring and repositioning. We look into the transformations at stake in the automotive sector, one of the main industries targeted by the environmental regulations and sectoral restructuring due to the shift of production to electrification, that is implying a deep and wide conversion of productive facilities of the sector. We look at the Italian context that is undergoing pervasive structural changes as the progressive dismantling of the main national player and the national political contexts is lacking to provide for ad-hoc industrial policy solutions to steer the sector up, also to cope with the challenges of decarbonization. We propose a mixed-method strategy that combines a quantitative and descriptive firms' patterns' analysis and a qualitative workplace study. We

compare two components' manufacturers both located in Tuscany, a high value endowed area characterised by the presence of universities and incumbents on the market. The two facilities are in fact characterised by a core positioning in the sector. We use company level data by Orbis IP and semi-structured interviews conducted with engineers, managers, workers and workers' representatives.

Neither of the two cases can be defined as a successful case of transition. We define Case I as a case of tentative transition and Case II of failed transition. The former has partially shifted the production to an electrified product, but the volumes are still marginal, the product development is managed in another plant of the group and electric/electronics skills are still lacking in the plant of reference. The latter has failed to convert the production despite the particular effort in adapting skills and developing alternative technologies to be able to cope with the transition. After the past ownership had declared the plant to be subject to 750 redundancies given the strategy to phase out from the fuel combustion segment and the plant being a producers of ICEs injectors, the plant was bought by a new owner which has kept the original business in the ICE segment.

With respect to the implications of decarbonization on GVC restructuring, Case I has shifted to Tier 1 to Tier 2 in some businesses.

From this two-level analysis, a partial discrepancy emerges between the strategies and capabilities of the multinational company and the dynamics specifically affecting the plants studied. The more modest patenting activity in Case I is associated with the tentative transition of the plant. At the same time, in Case I we observe a reconfiguration -subordinated to the decarbonisation process- in the geography of the production segment of the Tuscan plant. At the more sustained commitment to innovative activity also in the technologies for decarbonisation in Case II, we observe a lack of transition. The latter, as mentioned in the workplace-based analysis, is also linked to a weakness in the outlet market for the electric product. Thus, after the crisis of the plant, the latter continues the production of components for ICEs. Nevertheless, from the workplace-based analysis we are led to say that in both cases the plants undergo a repositioning towards more peripheral positions of the production geographies. And while the decarbonisation process certainly plays a decisive role in the recomposition of the automotive value chain, the reason for the increasing subordination of the plants studied lies in other dynamics. Among the various structural factors, the lack of an industrial policy at the national level capable of leading this restructuring of production, together with the weak and lagging involvement of other social actors in the development phase, are in fact relegating Italy to an increasingly peripheral role in global production geographies.

Overall, the process of decarbonization is non neutral in the restructuring and repositioning of the GVC. Industrial policy and ad hoc public interventions accompanying the decarbonization process are crucial to avoid a confinement or even loss of core centres and their capabilities to cope with transformations, in particular to avoid threats to workforce dismissal and loss of productive capacity across territories.

The further development of the research will be to follow-up on the two Cases and to extend the comparative analysis to (i) more cases to provide for a more comprehensive analysis of the Italian automotive sector; (ii) other European countries to observe the role of institutional factors as the presence of industrial policies and different industrial relations and collective agreements.

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